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Why American Higher Education Needs Parasitologists

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Although there are some more formal acknowledgments at the end, I would like to thank all of you for the honor of being elected President of ASP. This past year has been a very rewarding, although in some cases challenging, experience. I have always considered ASP to be a very open organization, offering many opportunities for professional development and interaction between members of all ages and stages in their careers, and I now know that those opportunities extend throughout our lives. So on behalf of Council, I also thank all of you for your work on behalf of the society and for your participation in these meetings.

Today I'm going to address 4 topics that I believe not only characterize the discipline of parasitology, but also are largely missing from our national conversation about education, especially at the college and university level. Those topics are the production of transferable skills; our perceptions of the world, especially the natural world; access to reasonably difficult problems in natural settings; and intellectual epidemiology, or the movement of ideas, innovations, and cultural items through populations. These topics seem to have been a part of my discussions with fellow parasitologists for at least half a century, beginning with my choice to pursue a graduate degree under the supervision of Dr. J. Teague Self at the University of Oklahoma, so it seems natural to finish a career in the same way it started.

My first ASP meeting was in June 1962, at the Mayflower Hotel in Washington, D.C. I had just become 1 of Self's graduate students, and along with 2 others—Jerry Esch, later to become editor of the *Journal of Parasitology*, and Jim McDaniel, now deceased—drove from Norman to Washington in Jim's car. Two experiences during that first ASP meeting left a lasting impression on me; one was a tour of the National Institutes of Health, during which Dr. Self introduced me to G. Robert Coatney; the other happened on Wednesday afternoon, June 13, when Ray Cable moderated a symposium entitled "The Future of Teaching in Parasitology." Not only did those encounters make a lasting impression, they formed the basis for my mentoring philosophy during the next 50 yr, and they are the main reason I believe American higher education is in desperate need of parasitologists on the faculty.

At NIH, as we walked down a hallway, I heard a blustery Irish voice coming out of one of the offices. Dr. Self grinned and said, "How'd you like to meet Coatney?" I had just started thinking about a doctoral project on bird malaria, so that question was the rough equivalent of saying "How'd you like to meet one of your most famous heroes?" We went into the office where Dr. Coatney was holding forth with a couple of colleagues. After we were introduced, he passed along his version of the Andrew Carnegie rules for success, again in that wonderful tone of voice: surround yourself with people smarter than you are; get out their way and let them work; then go out and brag about what they did. Then he added: and always be finishing something. Later, as a faculty member at the University of Nebraska–Lincoln, I found those rules amazingly easy to follow, especially the first one!

TRANSFERABLE SKILLS AND THE OLSEN LESSONS

I didn't personally meet O. Wilfred Olsen, the opening speaker in Cable's symposium, but I've never forgotten what he said, in essence, that to get a Master's degree in his laboratory, a student had to describe a new species, and to get a Ph.D., a student needed to work out a life cycle. In the half-century since that first ASP meeting, even as molecular technology has completely changed our view of biology, and thus altered our vision of how a biologist should conduct his or her work, as well as our list of questions and appropriate answers, Olsen's reasons for requiring those particular tasks for graduate degrees have remained remarkably valid. Most undergraduates taking biology classes in an American college or university are deluged with information, tested over their abilities to supply correct answers, and supposedly introduced to real science with standard exercises that generate predictable results during a 3-hr lab. Rarely if ever do they get asked the most pervasive and persistent question in biology, namely, *what is it*? And even more rarely are they given the task of trying to answer that question using relevant literature.

To illustrate what happens when a parasitologist approaches that "what is it?' question, often leading to the description of a new species, I've chosen specimens found by Dr. Scott Gardner, a colleague at the University of Nebraska–Lincoln and curator of parasitology at the Harold W. Manter Laboratory in the University of Nebraska State Museum. Scott has done field work in numerous places, including Latin America and Mongolia. At one of our seminars, he began with a set of hooks, from Mongolia, that any parasitologist would immediately recognize as those of a cestode (Fig. 1). We can imagine an introductory biology course lab practical in which this specimen is on a microscope stage and beside the scope is a card with 2 questions typical of such exams: (a) What is it? (b) To what phylum and class does this organism belong? And that's where the inquiry would end. As parasitologists, however, we continue with questions and eventually assemble the answers into a picture that represents not only the information surrounding this specimen, but also the inclusive world view so typical of our discipline.

The hooks are from a protoscolex of *Echinococcus multilocularis*. This species occurs throughout much of the northern hemisphere above about latitude 45°N. Adult cestodes are found mainly in canines, especially foxes, and larvae are in rodents, typically voles of the genus *Microtus* (Fig. 2). Dissection of an individual *Microtus limnophilus* reveals gross anatomy and pathology of multilocular cysts (Figs. 3, 4). Paraffin sections remind us of the tissue-level relationship between host and parasite, as well as of those hours learning the histological arts so we could make an observation that would be impossible without them (Fig. 5). Host identification brings up significant zoogeographic questions because this species of *Microtus* from Mongolia

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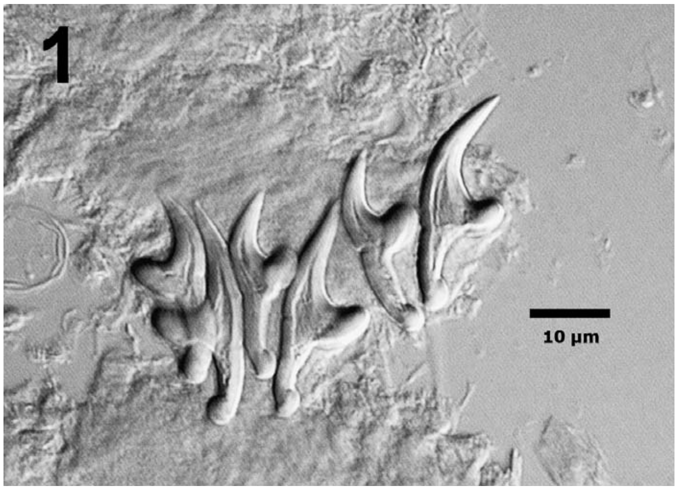


FIGURE 1. Hooks from a protoscolex of *Echinococcus multilocularis*.

is in the same genus as rodents living in my backyard in Lincoln, Nebraska (Figs. 2, 3). The tag in Figure 3 symbolizes our obligation to preserve tangible evidence—in the form of skins, skull, and tissue samples for later molecular analysis—that we've identified our hosts correctly. Collection site images remind us of the impact ecological settings have on parasite transmission (Fig. 6). The gers and Mongolian family are symbols of cultural traditions and both the constraints and opportunities they provide regardless of the places we work (Fig. 7). Every parasitologist understands how physical geography influences the transmission of infectious agents (Fig. 8), and pins on a map remind us not only of the logistical burdens typically associated with exploration (Fig. 9), but also the fun and fellowship associated with expeditions.

Parasitologists are, almost by definition, aware that this set of hooks (Fig. 1) is actually embedded in a matrix of such information (Figs. 2–9), much of it supplied by technology, some of it centuries old, and taken as a whole giving us a view of the world not unlike that provided by a collection of lenses of varying magnification affixed to cameras and microscopes. These metaphorical lenses make us think about phylogeny even as we sit and measure specimens, wonder about resident parasite fauna whenever we see a wild animal, or even a picture of one, and remember humanity's historical, and ongoing, global interactions with infectious agents of economic importance whenever we pick up a newspaper filled with our latest military adventures. And, in this sense, they are the same set of "lenses" used by artists and writers.

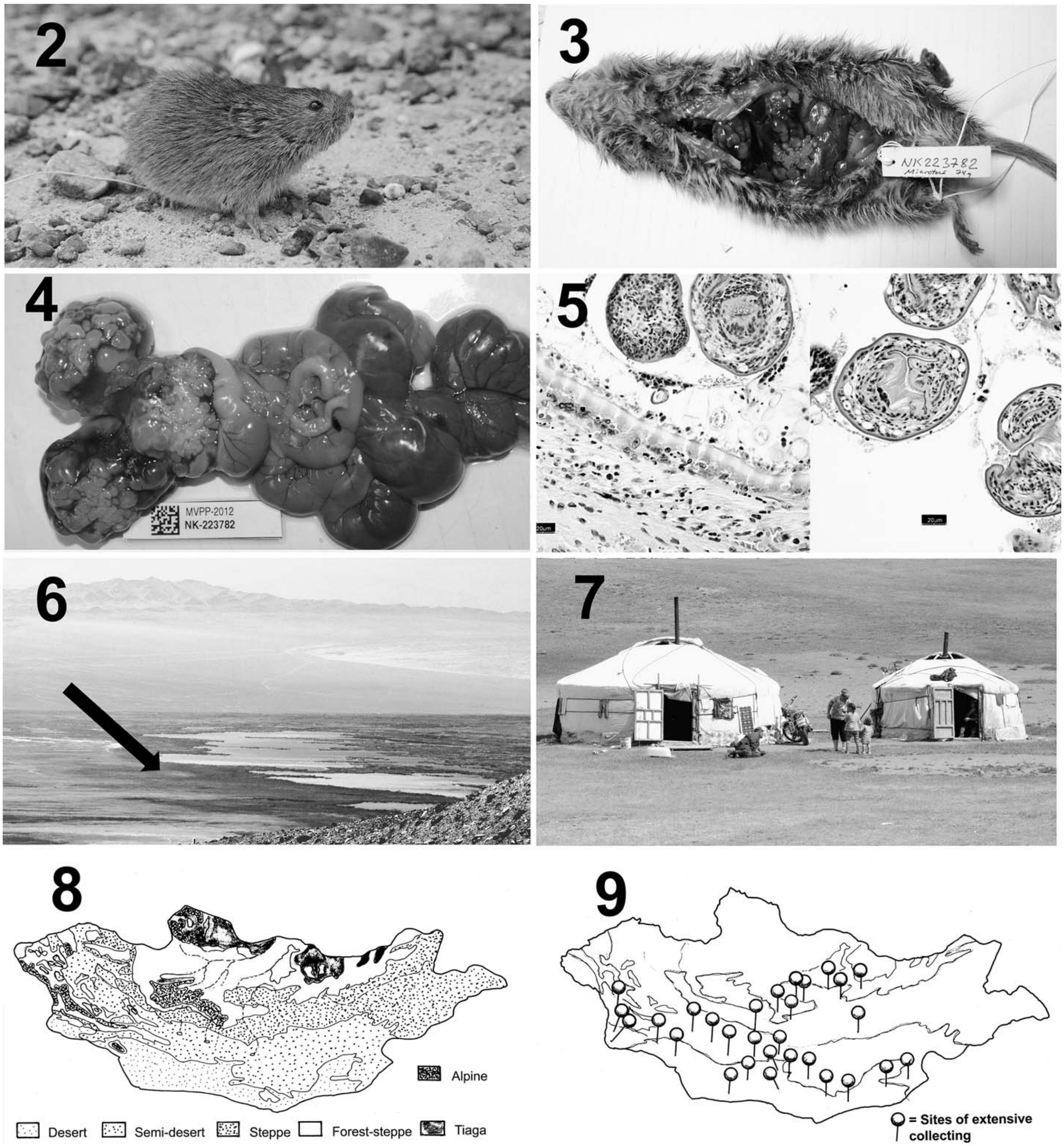
These intellectual habits may not be unique with parasitologists, but they are deeply ingrained in the discipline and probably derived from the fact that every parasite has at least 1 host, and often several, that must be identified and an ecological gauntlet that must be traversed before a life cycle is completed. We tend to talk in historical, geographic, ecological, and phylogenetic terms regardless of who is listening, a kind of conversation that is especially important to a nation whose political discourse is often best described as willfully narrow. If our colleges and universities are filled with potential business and political leaders, then American higher education needs the kind of thinking, and conversations, that parasitologists bring to the table. Life is not 30-sec sound bite sample, and flawed ideas can be as infective as any of the dozens of parasite species that live in and on human beings. That's why American higher education needs the intellectual breadth of parasitologists.

Olsen's requirement for a Master's degree—the description of a new species—is actually an extended response to that question: *what is it*? When the initial answer is *I don't know and can't seem to figure it out from the literature*, a student begins to suspect that he or she is dealing with an undescribed species. That suspicion sets in motion a set of actions that inevitably produce a remarkable set of transferable skills. From watching my own grad students and fellow parasitologists describe new species over the years, it became obvious to me that this activity involved the following:

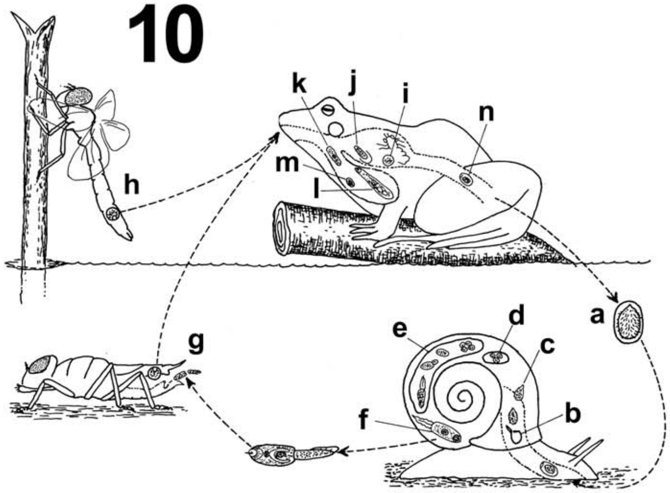
(1) Field work and collecting, sometimes arduous travel, opportunistic behavior, and a sense of what to actually look for
(2) A struggle with arcane literature, often in several languages, and typically involving a lesson in the administration of library resources
(3) A history lesson, focusing on other scientists' choices of what observations to make, the technology used in making and recording those observations, their decisions relative to some biological materials, and rationale supporting such decisions
(4) A struggle with the question of how to represent a piece of nature, often a microscopic piece, so that some other person, decades from now, in some far-off part of the world, will know *exactly* what you were describing
(5) An option to make some word—a specific epithet—relatively immortal, embedded in the primary literature as long as that literature exists on Earth
(6) About the only thing you might do in academia in which your inadequacies will be forever remembered and treated with respect (as when your new species gets synonymized in exceedingly neutral language) and
(7) A serious lesson both in art and in the technology of producing it.

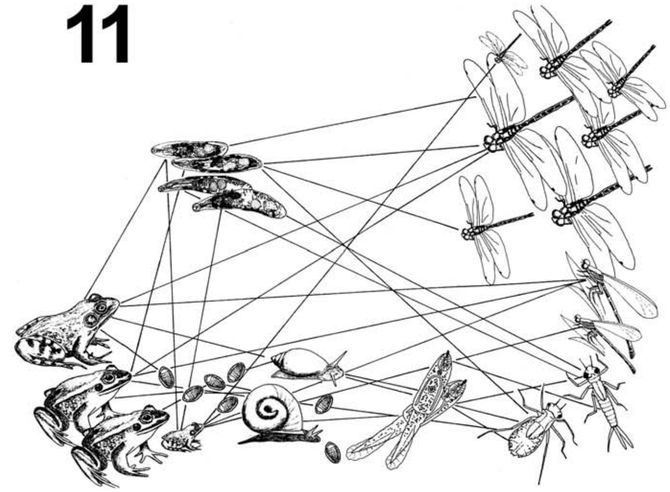
The new species that I've had a hand in describing, including those by my students and colleagues working with my students, are in 4 different phyla—Platyhelminthes, Apicomplexa, Myxozoa, and Euglenozoa—as well as several genera within a single phylum (Self and Janovy, 1965; Daggett et al., 1972; Janovy et al., 1989, 2007; Richardson and Janovy, 1990; Clopton et al., 1991, 1992, 1993; Ferdig et al., 1991; Percival et al., 1995; Helt et al., 2003; Jirků et al., 2006). Although this list is far short of those compiled by parasitologists working primarily in systematics, what I've come to call the "Olsen lessons" were learned not only by me, but also, and more importantly, by my students in the act of compiling it.

I can assure you that had I gone to our graduate admissions committee and declared my intent to ask a potential graduate student to describe a new species for his or her M.S. thesis, I would have been viewed with the kind of suspicion I've come to expect in conversations with non-parasitologists, conversations that usually contain phrases like "oh, that's just taxonomy," spoken in a thinly disguised depreciating tone. And it's not just my own colleagues at my own institution of higher learning who might react in such a way. Past ASP presidents have, at various times over the past century, also noted non-parasitologists' lack



FIGURES 2–9. (**2**) *Microtus limnophilus*, one of the potential hosts of *Echinococcus* species in Mongolia. (**3**) *Microtus limnophilus*, host of *Echinococcus multilocularis*, collected near Hovd, Har Us Lake, Hovd Provence, Mongolia, and dissected to show the multilocular cyst. (**4**) Viscera of *Microtus limnophilus* specimen from Figure 3, with multilocular cyst permeating the liver. (**5**) Tissue sections of *Echinococcus multilocularis* cyst and protoscolices within the cyst. (**6**) Approximate collection site (arrow) of the *Microtus limnophilus* specimen in Figure 3. (**7**) Gers and family life, the cultural matrix that overlaps the *Echinococcus multilocularis* distribution and scientists' collecting activities in Mongolia. (**8**) Physical geography of Mongolia as encountered by scientists collecting in that part of the world. (**9**) Sites of extensive collecting in Mongolia by museum scientists over a several year period.





FIGURES 10, 11. The scheme of things: (**10**) a diagram of the *Haematoloechus medioplexus* life cycle. Redrawn from Olsen (1974). The way things are: (**11**) A highly simplified illustration of ecological and trophic relationships between species of frog lung flukes and their various hosts in nature.

of understanding of our discipline (Hall, 1932; Kemp, 1989; Holmes, 1991). But did our students describing new species carry away the transferable skills that O. W. Olsen had also come to appreciate as he produced students who would later become Ward medalists? Yes; and that's another reason why American higher education needs parasitologists.

PERCEPTIONS OF THE NATURAL WORLD

The phrase "work out a life cycle" could easily be considered the parasitological equivalent of an addictive narcotic, a loaded trap, a metaphorical black hole, a life lesson in the capriciousness of serendipity, a classic struggle between human beings versus dumb, microscopic, and uncooperative animals, an allegory worthy of a doctorate degree in English, training for a career as a mystery novelist, and one of the most humbling and maturing experiences available to any individual with access to a laboratory, glassware, aquaria, nets, guns, a microscope, a dependable vehicle, and a healthy credit card. Small wonder Olsen asked his doctoral students to engage in such an adventure and find a natural setting in which to do the work.

Regardless of how daunting life cycle diagrams may seem to undergraduates, especially when labeled with terms for developmental stages (see Roberts et al., 2013), such figures as found in textbooks can be considered a scheme of things. That phrase, "scheme of things," is the title of an Allen Wheelis (1980) novel in which the protagonist claims "beginning as our view of the world, it [the scheme of things] finally *becomes* our world." The mathematician Douglas Hofstadter in his book *Metamagical Themas* (1985) further illustrates this evolution of a "scheme of things" into "the way things are" (the title of another Wheelis novel) with his examples of self-replicating memes. Were he still alive, however, I strongly suspect that O. W. Olsen, from watching his doctoral students struggle with their projects, would understand completely how life cycle diagrams can, in the minds of non-parasitologists, become the way things are—that is, an organized view of something complicated and at times beyond human control.

In the Wheelis novels "the way things are" is "the raw nature of existence, unadorned" (Wheelis, 1980), whereas a scheme of things is a human construct designed to make sense of that nature. Thus a diagram such as the life cycle of *Haematoloechus medioplexus* (Fig. 10) conveys the idea that a trematode's life is organized into a well-ordered sequence of events. The figure suggests questions about how a natural system operates. For example, do the worms harm the host? Do the parasites interfere with mating by inhibiting a male frog's calling ability? Do parasite larvae influence dragonfly behavior, thus making intermediate hosts more likely to be eaten by a frog than they would be otherwise? The questions are legitimate ones, although clearly derived from a human perspective, a result of our attempts to organize nature and our perhaps instinctive worry about infectious agents that harm us.

Such questions not only are based on our assumption that the scheme of things is the way things are, they also constrain the range of appropriate answers, thus the kind of research to be conducted on a system. I suspect that very few non-parasitologists want to hear "on an evolutionary scale, it doesn't matter" as an answer to any of these questions in the paragraph above. Nor would a business executive or politician appreciate the fact that there are realms, like parasitism—the most common way of life among animals on Earth—in which schemes of things do not necessarily reflect the way things are. With respect to life cycles, for example, the question that is of most ecological and evolutionary significance is: What factors actually influence the flow of parasite tissue, thus genetic information, through an ecosystem? In other words, what, really, is the way things are?

Figure 11 is my attempt to illustrate the realm of possible answers to this last question. In nature, most parasitic relationships are embedded in a complex array of trophic and ecological interactions instead of a well-ordered scheme-of-things life cycle diagram. Furthermore, this array can easily differ in substantial ways from region to region, and even from site to site within a region, as demonstrated by the work of Bolek and Janovy (2007a, 2007b), Bolek et al. (2009, 2010), and Langford and Janovy (2009). My impression, based on years of listening to non-parasitologists talk about parasitism, is that non-parasitologists are curious mainly about how parasites damage hosts, and in all fairness, that curiosity also drives the global enterprise in medical and veterinary parasitology. But we need to remember that the vast majority of animal parasites are not of medical or veterinary importance, and a student's attempt to answer questions about how any of these species are really maintained in nature usually leads to an adventure that validates Olsen's choice of life cycles as problems worthy of doctorate degrees. What those doctoral students also need, however, is a place to work.

ACCESS TO REASONABLY DIFFICULT PROBLEMS

In his book *Parasites, People, and Places* (2004) Gerald Esch explores the role that biological field stations have played in the development of careers in parasitology and of the discipline itself. What these stations really provide is ready access to natural areas where we can find reasonably difficult problems and be taught a powerful lesson in the way things are. It doesn't take much collecting in one of these places to remind us of just how pervasive parasitism is and how diverse are the ways in which it is manifested. We see principles such as host specificity, aggregated population distributions, and parasite species restricted to host age or developmental stages, all in a variety of host-parasite systems. But in retrospect, we also see how parasitologists can produce certain important contributions when they have ready access to stable environments, and how remarkably difficult it is to answer some seemingly simple questions raised by a decision to go exploring.

Among the many possible sites, I've chosen 3 to illustrate the above points: Carpinteria Marsh in California, Charlie's Pond in North Carolina, and Nevens Ranch in western Nebraska. Carpinteria Marsh is 1 of the coastal habitats studied extensively by Armand Kuris and his colleagues at the University of California Santa Barbara; Charlie's Pond has been a productive study area for Gerald Esch's students at Wake Forest University for decades; and the western Nebraska sites, so readily accessible because of the nearby Cedar Point Biological Station (CPBS), have been favorites of my own students, both undergraduate and graduate, as well as sources of material for the Field Parasitology course I taught at CPBS for 35 yr.

Carpinteria Marsh (39°24′N, 119°31.5′W) is 1 of 3 sites used by Kuris et al. (2008) in their research on coastal ecosystems. The methods were not particularly sophisticated and in fact involved about the same kind of techniques—dissections, counting, weighing, and identification—that are performed routinely by undergrads doing an honors research project in parasitology (Anderson et al., 1993; Bi and Janovy, 2011; Bunker et al., 2013). What is remarkable, however, is the thoroughness and insight involved in this work on distribution of biomass in the plant and animal communities, and regardless of the conclusions, the study serves as a model for an unbiased approach to the study of community ecology. The conclusions are rather eye-opening: "The biomass of trematodes was particularly high, being comparable to that of the abundant birds, fishes, burrowing shrimps and polychaetes" (Kuris et al., 2008).

The parasitologists involved in this study brought human traits to the task: patience, care, breadth of knowledge, and willingness to get into the field and probably get quite dirty. The results are a clear statement of the way things are. I suspect that if you sat in on ecology classes at most American colleges or universities, you'd rarely if ever hear the above quote or a discussion of the methods of study. In fact, you'd probably not even hear the word "parasite." Kuris and his colleagues (2008) are saying that if you ignore the parasites, you ignore a truly significant factor in the energy dynamics of ecosystems. That's another reason American higher education needs parasitologists.

Charlie's Pond (36°17′N, 80°3.5′W), about 30 km north of Winston-Salem, North Carolina, was the site for numerous studies, especially those on snail intermediate hosts, by students working in Esch's lab at Wake Forest University (Crews and Esch, 1986; Fernandez and Esch, 1991; Snyder and Esch, 1993; Sapp and Esch, 1994; Zelmer and Esch, 2000a, 200b; Fellis and Esch, 2004). As a product of that research we have a picture of parasite-first intermediate host relationships that could simply have not been assembled without long-term easy access to a natural area. In this sense, Charlie's Pond is similar to Carpinteria Marsh and other sites mentioned in Esch's (2004) book. As an example of such products, consider a conclusion from Fernandez and Esch (1991): "Antagonistic interactions between trematode species that occurred at the infracommunity level had a negligible effect on the composition and structure of the component community." In other words, here's a case in which interactions between species within a single individual host had little or no effect on the structure of a parasite community in the pond itself. I doubt very seriously that any non-parasitologist, perhaps committed to the idea that competition drives natural systems, would include such a statement in his or her lecture to students in an ecology class. And that's another reason American higher education needs parasitologists on the faculty.

The western Nebraska sites are accessible for 2 reasons: the generosity of local landowners and the presence of the Cedar Point Biological Station in Keith County. Dunwoody Pond (41°14′N, 101°34.5′W) and the Nevens Ranch well tank pond (41°12.5′N, 101°25′W) have been particularly important for both graduate and undergraduate students. The Nevens site has no fish but does support a sizeable bullfrog population. Typical studies made possible by such easy access include not only those on gregarine population dynamics (Logan et al., 2012; Bunker et al., 2013), but also frog lung fluke papers such as those by Snyder and Janovy (1996) and Bolek et al. (2010). The trematode work has been particularly revealing, showing that movements of parasites through ecosystems may be controlled in ways rarely envisioned by non-parasitologists studying life cycle diagrams such as those in Figure 10. Instead, consider the quote from Snyder and Janovy (1996): "The evolution of disparate patterns of behavior among the cercariae of these 4 congeners has directly affected subsequent patterns of transmission to the definitive host." In other words, the rate-limiting step in this scheme of things is really the behavior of parasite larval stages.

In all 3 of these examples, the combination of ready access to natural sites (the way things are) and human ingenuity unfettered by a scheme of things has produced significant conceptual contributions. Parasitologists have always seemed to be able to take advantage of opportunities such as those provided by Carpinteria Marsh, Charlie's Pond, and Nevens Ranch, in a way that other biologists seem reluctant to do. Thus parasitologists seem to go looking for new questions and problems instead of systems to test some preexisting scheme of things. That habit, and the willingness to use it, is yet another reason American higher education needs parasitologists on the faculty.

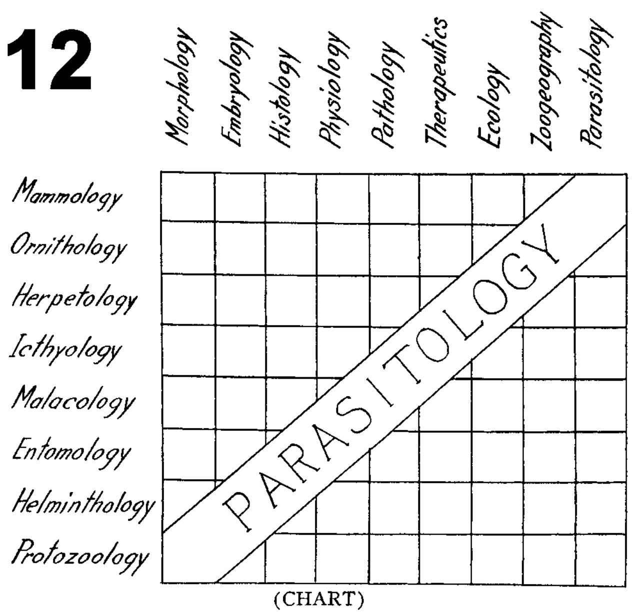


FIGURE 12. The nature of parasitology as portrayed by former ASP president M. C. Hall (1933).

INTELLECTUAL EPIDEMIOLOGY, OR THE MOVEMENT OF IDEAS

Cavalli-Sforza and Feldman's *Cultural Transmission and Evolution* (1981) was my first exposure to the assertion that words, phrases, and ideas could have properties that up until that time I'd associated only with infectious agents. Hofstader, in *Metamagical Themas* (1985), expanded on that assertion, even suggesting ways that the infectivity of phrases and ideas could be enhanced, even making them self-replicating, analogous to microparasites such as trypanosomes. In the opening years of the 21st century, perhaps our most familiar technology is hand-held, an adjective that can be applied to smart phones, game consoles, small libraries (e-readers), computers, digital cameras with computer capabilities, global positioning systems, and even DNA sequencers (http://www.otago.ac.nz/news/news/otago077848.html). Indeed, a visit to any American college campus confirms the fact that the so-called smart phone has infected our students, altering their behavior, focusing their attention on that small touch screen, and separating them from the natural world, even if that nature is only campus landscaping.

Statistics regarding this infection by technology are readily available from several sources, for example, www.higheredtechdecisions.com. According to that web site:

(1) Two-thirds of 18–24 yr olds have smart phones, and that number grew by 14% in the last year for which we have complete data (2012–2013).
(2) "Breaking news" and the weather make up over 80% of the information accessed by college students on their own, but over 80% of them also use it for school-related activities, presumably assigned by faculty members.
(3) Well over 70% of students check their smart phones first thing in the morning and the last thing at night, and nearly half of them use their phones in the bathroom.
(4) None of the top 10 ways in which students use smart phones includes reading serious literature (the *Journal of Parasitology* is now available on mobile devices).
(5) Finally, Thomas Keuhl, president of Campus Nation Network, bemoans the fact that so few schools have exploited the power of digital interactive signage, claiming "This melting of the boundary between advertising and entertainment in digital signage and then implementing it with mobile—that's the future" (www.higheredtechdecisions.com).

Faculty members, especially in the sciences, and administrators are increasingly complicit in this effort to change the fundamental nature of American higher education, admitting, it sometimes seems, that if you can't beat them join them. The "them" in this case is that amorphous collection of people and corporations with a vested interest in information technology and a keen sense of the market potential in 5 million college students and their parents, already shelling out, and often borrowing in order to do it, anywhere from $23,000 to $45,000 per year per student for attendance at a local public college or an average private college, respectively (www.collegedata.com). Anyone who has taught freshman biology in the last decade is familiar with the readily available arsenal of digital aids, including online content collections, prepared PowerPoints, course management software, classroom response systems ("clickers"), and in some cases complete curricula (see home.pearsonhighered.com and www.cmu.edu/teaching/technology for examples of such resources).

Added to that technological onslaught are the impact of high college costs on both student behavior and student goals, massive open online courses (www.coursera.org), trendy approaches to teaching such as flipped classrooms (www.knewton.com/flipped-classroom), and the cumulative effects of standardized testing (Zhao, 2009; Aviv, 2014). My impression, shared by many colleagues, is that these forces are shaping our nation's intellectual resources in a way that is not necessarily consistent with the traditional ideals of American higher education (Delbanco, 2012; see also http://chronicle.com/article/College-at-Risk/130893/). Yet it doesn't take much of a hands-on field experience, especially under the guidance of a parasitologist, to capture that sense of wonder, re-kindle the kind of curiosity that flourishes in an exploratory situation, and foster the multi-lens view of nature described above (Janovy, 1994, 2003; Esch, 2004; Janovy and Major, 2009). I've seen it happen countless times: cut open a host, find parasites, wonder how they got there, get introduced to relevant literature, struggle through the art of specimen preparation, talk about your experience with people who appreciate the seductive power of discovery, and you're hooked.

I am convinced that parasitology, by its very nature, teaches breadth, historical perspective, and language skills far more successfully than do most if not all other areas of biology. When a student discovers that methods of data analysis applied to a problem involving protistan parasites of insects can easily be applied to a problem involving distribution of pathogenic helminths among humans or domestic animals, the power of our discipline is revealed. This power is in the breadth required to understand a parasitic relationship, a property described most effectively by Maurice Hall (1933) in a figure to accompany his ASP presidential address (Fig. 12). I am also convinced that if a person can read a single issue of the *Journal of Parasitology* and understand as well as appreciate at least half of what is printed in that issue, that person is more broadly educated than most of the biology faculty members hired by colleges and universities in the United States during the past decade. In a rapidly changing world, breadth and transferable skills are empowering attributes. Every parasitologist knows, like every parasitologist since Henry Baldwin Ward has known, that breadth and transferable skills are the defining traits of our discipline.

So it's a very challenging academic world in the opening years of a century that promises conflict, both cultural and military, technological innovations that surprise a population accustomed to constant use of personal gadgets that might have been imagined in 1950s science fiction, and money-driven changes that are rapidly eroding the ideals of American higher education. In the heady days following World War II, Asa Chandler's (1946) observation that parasitologists, like orchids, take a long time to mature but eventually become objects of great intellectual beauty was then, and remains today, a compelling metaphor. But when we carry in our pockets computing power far in excess of that needed to land Neil Armstrong on the moon, global communication from a park bench is measured in seconds for all of us, our students are inventing new languages as adaptations to their communication power, and every college president asks first "How much does it cost?", any parasitologist who seeks a position in the Ivory Tower cannot wait to develop into that metaphorical orchid.

Instead, as I look over the younger generation of parasitologists, the successful ones make me think that a parasitologist is like a coyote. He or she is cunning, resourceful, adaptable, omnivorous, albeit in an intellectual sense, not easily frightened, and able to survive in seemingly hostile environments. Such coyotes are beautiful in their own way, but most of all they can, and will, "sing" through the night, delivering elegant and insightful stories about parasitism, the most common way of life on Earth, in a language, and for reasons, that the lesser creatures simply cannot seem to understand. American higher education has never been in such desperate need of this kind of intellect as it is today.

ACKNOWLEDGMENTS

I need to begin the formal acknowledgments with recognition of my wife, Karen, and our three children, Cynthia Anne, Jenifer Lynn, and John III, who for half a century violated the first rule of polite dining, which is to never invite a parasitologist to dinner. As a result of such an invitation, they ended up at many ASP meetings over the years. All of my former graduate students and fellow parasitologists have contributed significantly to the ideas presented in this talk. A number of western Nebraska ranch families, especially Duane and Lois Dunwoody and Jim and Lee Sillesen, opened up their land to parasitologists for at least 35 yr, and in so doing illustrated the kind of access that is discussed above. Several of my colleagues at the University of Nebraska–Lincoln, especially Brent Nickol, demonstrated clearly why American higher education needs parasitologists. My *Foundations of Parasitology* (Roberts et al., 2013) coauthors Larry Roberts and Steve Nadler have been important contributors to the teaching concepts described above. Of the approximately 15,000 undergraduates to whom I have given grades, I owe a debt of gratitude because about 1 out of every 100 ended up doing some kind of independent study in our lab, and about 1 out of 1,000 either stayed to do graduate work, or returned after graduate work elsewhere. Among the latter group are included several members of ASP Council, past and present, committee members and chairs, and mentors now bringing their own students to our meetings. Talia Everding and Michelle Rogers are 2 undergraduates who worked in my office; they did a lot of the library work to support both the oral presentation and this printed version. Don Duszynski, Scott Gardner, Mike Zimmermann, and Armand Kuris all supplied pictures used in the oral presentation in New Orleans; Scott was particularly generous with the photographs for Figs. 1–9 and reviewed a draft of this paper. Sue Ann Gardner helped with the permissions needed to use a modified version of the Olsen life cycle figure.

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